5-V Low-Power Comparators with Open Drain Output

Features

- Power Supply Voltage: 2.5 V to 5.5 V
- Low Supply Current: 50 μA per Channel
- High-to-Low Propagation Delay: 120 ns
- Internal Hysteresis Ensures Clean Switching
- Offset Voltage: ±4 mV
- Input Bias Current: 30 pA Typical
- Input Common-Mode Range Extends 100 mV
- No ESD Diode at both Input Pin to +Vs and Output Pin to +Vs
- Open-Drain Output for Maximum Flexibility

Applications

- Peak and Zero-crossing Detectors
- Threshold Detectors/Discriminators
- Sensing at the Ground or Supply Line
- Logic Level Shifting or Translation
- Window Comparators
- IR Receivers

Description

The devices in this series consist of one or two comparators on a single monolithic substrate. The common-mode input voltage range includes ground and power even when operated from a single supply, and the low power supply current drain makes these comparators suitable for battery operation. The devices are designed to directly interface with TTL and CMOS, the outputs can be connected to other open-collector or open-drain outputs to achieve wired-AND relationships.

The devices are specified for the temperature range from −40°C to +125°C.

Typical Application Circuit

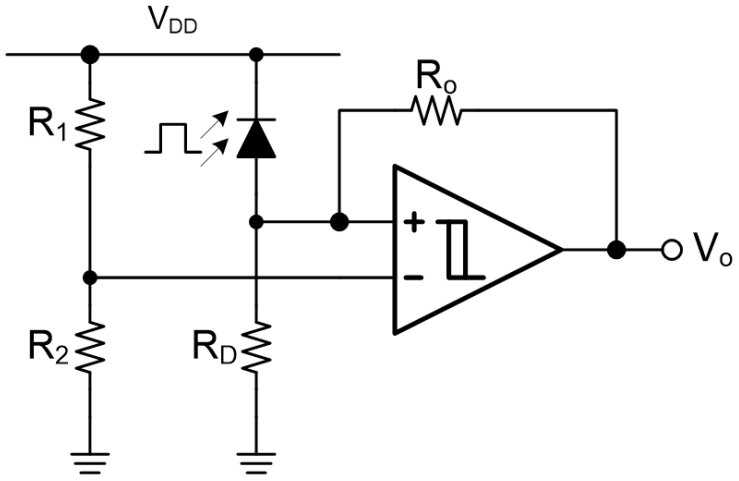


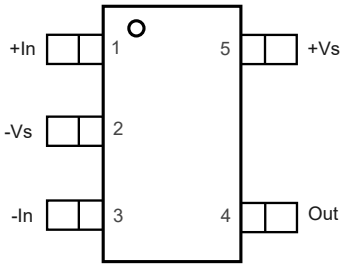
Table of Contents

Revision History

Date	Revision	Notes
2023-09-03	Rev.A.0	Initial version.
2024-01-22	Rev.A.1	Added the chapter: Detailed Description, including some performance description and block diagram. Added the ESD diode description in the "Features".
2024-02-15	Rev.A.2	Modified the pin configuration of SOP8. The physical object has not changed, just acorrection of hand writing errors.

Pin Configuration and Functions

LMV331X
SOT23-5 Package
Top View



LMV331X
SOT353-5(SC70) Package
Top View

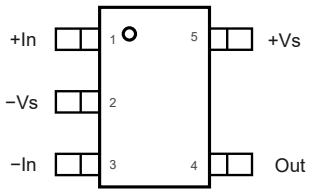
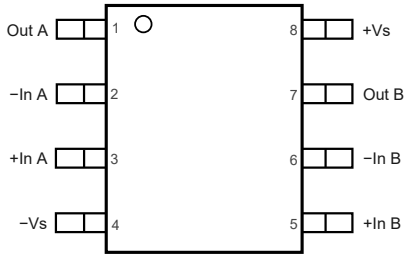


Table 1. Pin Functions: LMV331X

Pin No.	Name	I/O	Description
4	Out	O	Output
2	$-V_S$	-	Negative power supply
1	+In	I	Noninverting input
3	−In	I	Inverting input
5	$+V_S$	-	Positive power supply

LMV393X
SOP8 Package
Top View



LMV393X
MSOP8 Package
Top View

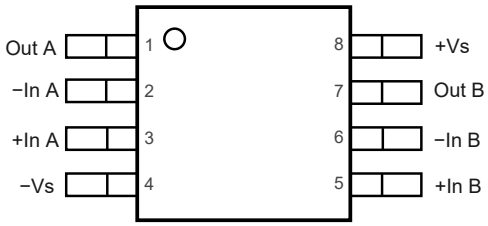


Table 2. Pin Functions: LMV393X

Pin No.	Name	I/O	Description
1	Out A	O	Output
2	−In A	I	Inverting input
3	+In A	I	Noninverting input
4	$-V_S$	-	Negative power supply
5	+In B	I	Noninverting input
6	−In B	I	Inverting input
7	Out B	O	Output
8	$+V_S$		Positive power supply

Specifications

Absolute Maximum Ratings (1)

Parameter		Min	Max	Unit
	Supply Voltage, $(+V_S) – (-V_S)$		6.5	V
	Input Voltage	$(-V_S) – 0.3$	6.5	V
	Input Current: +IN, −IN (2)	−10	+10	mA
	Output Current: OUT	−10	+10	mA
	Output Short-Circuit Duration (3)		Thermal protection	
T_J	Maximum Junction Temperature		150	°C
T_A	Operating Temperature Range	−40	125	°C
T_{STG}	Storage Temperature Range	–65	150	°C
T_L	Lead Temperature (Soldering 10 sec)		260	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. Exposure to any Absolute Maximum Rating condition for extended periods may affect device reliability and lifetime.
(2) The inputs are protected by ESD protection diodes to each power supply. If the input extends more than 500 mV beyond the negative power supply, the input current should be limited to less than 10 mA.
(3) A heat sink may be required to keep the junction temperature below the absolute maximum. This depends on the power supply voltage and how many comparators are shorted. Thermal resistance varies with the amount of PC board metal connected to the package. The specified values are for short traces connected to the leads.

ESD, Electrostatic Discharge Protection

Parameter		Condition	Level	Unit
HBM	Human Body Model ESD	ANSI/ESDA/JEDEC JS-001 (1)	4	kV
CDM	Charged Device Model ESD	ANSI/ESDA/JEDEC JS-002 (2)	1.5	kV

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

Recommended Operating Conditions

Parameter		Min	Typ	Max	Unit
V_S	Supply Voltage, $(+V_S) – (-V_S)$	2.5		5.5	V

Thermal Information

Package Type	θ_{JA}	θ_{JC}	Unit
SOT353 (SC70-5)	400	150	°C/W
SOT23-5	250	81	°C/W
SOP8	158	43	°C/W

Package Type	θ_{JA}	θ_{JC}	Unit
MSOP8	210	45	°C/W

Electrical Characteristics

All test conditions: V_S = 5 V, $R_{PULL-UP}$ = 5.1k, T_A = 25°C, unless otherwise noted.

Parameter		Conditions		Min	Typ	Max	Unit
Power Supply							
I_Q	Quiescent Current per Comparator	V_{CM} = 5 V			50	75	μA
		V_{CM} = 5 V, T_A = −40°C to 125°C				80	μA
PSRR	Power Supply Rejection Ratio	V_S = 2.5 V to 5 V, V_{CM} = 0 V		60	80		dB
		V_S = 2.5 V to 5 V, V_{CM} = 0 V, T_A = −40°C to 125°C		50			dB
Input Characteristics							
V_{OS}	Input Offset Voltage (1)	V_{CM} = 0 V to 5 V		−4	-0.5	4	mV
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C		−5		5	mV
	Input Offset Voltage Drift (2)	T_A = −40°C to 125°C			2		μV/°C
V_{HYST}	Input Hysteresis Voltage (1)	V_{CM} = 0 V to 5 V		1	4.5	10	mV
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C				15	mV
	Input Hysteresis Voltage Drift (2)	T_A = −40°C to 125°C			10		μV/°C
I_B	Input Bias Current (2)	V_{CM} = 2.5 V			30		pA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C				240	nA
I_{OS}	Input Offset Current (2)	V_{CM} = 2.5 V			30		pA
		V_{CM} = 2.5 V, T_A = −40°C to 125°C				240	nA
C_{IN}	Input Capacitance (4)	T_A = 25°C	Differential		3.5		pF
			Common Mode		6		
V_{CM}	Common-mode Input Voltage Range	T_A = −40°C to 125°C		($-V_S$) − 0.1		($+V_S$)+ 0.1	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0 V to 5 V		60	80		dB
		V_{CM} = 0 V to 5 V, T_A = −40°C to 125°C		50			dB
Output Characteristics							
I_{OH}	High-level Output Current (2)	V_{OH} = 5 V, V_{ID} = 1 V			1		nA
		V_{OH} = 5 V, V_{ID} = 1 V, T_A= −40°C to 125°C			100		nA
V_{OL}	Low-Level Output Voltage	I_{OL} = 1 mA, V_{ID} = −1 V			10	20	mV
		I_{OL} = 1 mA, V_{ID} = −1 V, T_A = −40°C to 125°C				50	mV
I_{OL}	Low-Level Output Current	V_{OL} = 1.5 V, V_{ID} = −1 V		80	120		mA
		V_{OL} = 1.5 V, V_{ID} = −1 V, T_A= −40°C to 125°C		50			mA
I_{SC}	Output Short-Circuit Current	Sink current,		85	125		mA
		Sink current, T_A= −40°C to 125°C		70			mA
Switching Characteristics, T_A = −40°C to 125°C (3)							

Parameter		Conditions	Min	Typ	Max	Unit
T_{PLH}	Propagation Delay Time, Low-to High	ΔV_{IN} = 1 V, V_{CM} = 0 V, 100mV overdrive, C_L = 15pF (2)		120	180	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 20mV overdrive, C_L = 15pF (2)		220		ns
T_{PHL}	Propagation Delay Time, High-to Low	ΔV_{IN} = 1 V, V_{CM} = 0 V, 100mV overdrive, C_L = 15pF (2)		110	170	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 20mV overdrive, C_L = 15pF (2)		222		ns
T_R	Rise Time	C_L = 15pF (2) (5)		181		ns
T_F	Fall Time	(2) (5)		0.81		ns

(1) The input offset voltage is the average of the input-referred trip points. The input hysteresis is the difference between the input-referred trip points.
(2) Provided by bench test and design simulation.
(3) Delay time is measured from mid-point of input to mid-point of output.
(4) Provided by design simulation.
(5) Measured between 10% of V_S and 90% of V_S.

Electrical Characteristics (continued)

All test condition is V_S = 2.5 V, $R_{PULL-UP}$ = 5.1k, T_A = 25°C, unless otherwise noted.

Parameter		Conditions		Min	Typ	Max	Unit
Power Supply							
I_Q	Quiescent Current per Comparator	V_{CM} = 2.5 V			53	90	μA
		V_{CM} = 2.5 V, T_A= −40°C to 125°C				100	μA
Input Characteristics							
V_{OS}	Input Offset Voltage (1)	V_{CM} = 0 V to 2.5 V		−4	-0.5	4	mV
		V_{CM} = 0 V to 2.5 V, T_A= −40°C to 125°C		−5		5	mV
	Input Offset Voltage Drift (2)	T_A= −40°C to 125°C			2		μV/°C
V_{HYST}	Input Hysteresis Voltage (1)	V_{CM} = 0 V to 2.5 V		1	4.5	10	mV
		V_{CM} = 0 V to 2.5 V, T_A= −40°C to 125°C				15	mV
	Input Hysteresis Voltage Drift (2)	T_A= −40°C to 125°C			10		μV/°C
I_B	Input Bias Current (2)	V_{CM} = 1.25 V			30		pA
		V_{CM} = 1.25 V, T_A= −40°C to 125°C				240000	pA
I_{OS}	Input Offset Current (2)	V_{CM} = 1.25 V			2		pA
		V_{CM} = 1.25 V, T_A= −40°C to 125°C				10	pA
C_{IN}	Input Capacitance (4)	T_A = 25°C	Differential		3.5		pF
			Common Mode		6		
V_{CM}	Common-mode Input Voltage Range	T_A = −40°C to 125°C		($-V_S$) − 0.1		($+V_S$)+ 0.1	V
CMRR	Common Mode Rejection Ratio	V_{CM} = 0 V to 2.5 V		60	75		dB
		V_{CM} = 0 V to 2.5 V, T_A = −40°C to 125°C		50			dB
Output Characteristics							
I_{OH}	High-level Output Current (4)	V_{OH} = 2.5 V, V_{ID} = 1 V			10		nA
		V_{OH} = 2.5 V, V_{ID} = 1 V, T_A= −40°C to 125°C					nA
V_{OL}	Low-Level Output Voltage	I_{OL} = 1 mA, V_{ID} = −1 V			15	20	mV
		I_{OL} = 1 mA, V_{ID} = −1 V, T_A= −40°C to 125°C				50	mV
I_{OL}	Low-Level Output Current (4)	V_{OL} = 1.5 V, V_{ID} = 1 V			45		mA
		V_{OL} = 1.5 V, V_{ID} = 1 V, T_A= −40°C to 125°C					mA
I_{SC}	Output Short-Circuit Current	Sink current		42	50		mA
		Sink current, T_A= −40°C to 125°C		35			mA
Switching Characteristics, T_A = −40°C to 125°C (3)							
T_{PLH}	Propagation delay time, low-to high	ΔV_{IN} = 1 V, V_{CM} = 0 V, 100mV overdrive, C_L = 15pF (4)			158	230	ns

Parameter		Conditions	Min	Typ	Max	Unit
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 20mV overdrive, C_L = 15pF (4)		280		ns
T_{PHL}	Propagation delay time, high-to low	ΔV_{IN} = 1 V, V_{CM} = 0 V, 100mV overdrive, C_L = 15pF (4)		120	230	ns
		ΔV_{IN} = 1 V, V_{CM} = 0 V, 20mV overdrive, C_L = 15pF (4)		223		ns
T_R	Rise time	C_L = 15pF (4) (5)		181		ns
T_F	Fall time	(2) (5)		1.5		ns

(1) The input offset voltage is the average of the input-referred trip points. The input hysteresis is the difference between the input-referred trip points.
(2) Provided by bench test and design simulation.
(3) Delay time is measured from mid-point of input to mid-point of output.
(4) Provided by design simulation.
(5) Measured between 10% of V_S and 90% of V_S.

Typical Performance Characteristics

All test conditions: V_S = 5 V, V_{CM} = 0 V, $R_{pull-up}$ = 5.1K, unless otherwise noted.

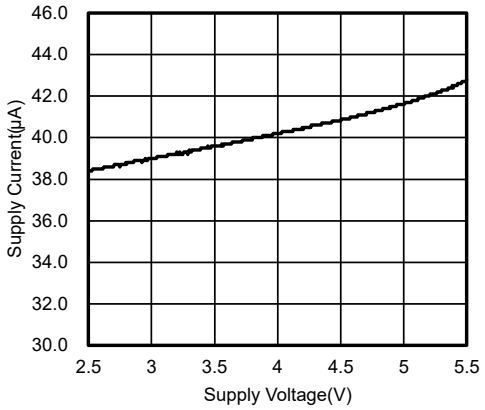


Figure 1. Supply Current vs. Supply Voltage, Output High (Single channel)

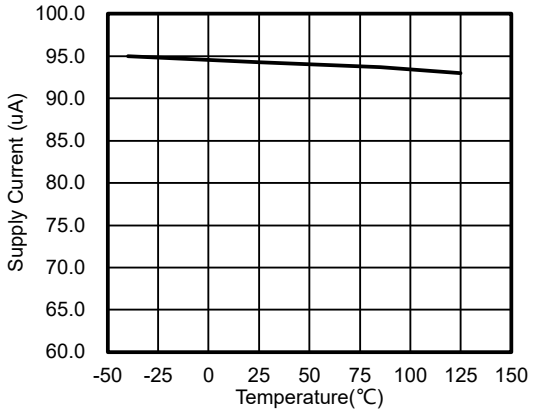


Figure 2. Supply Current vs Temperature (Dual channel)

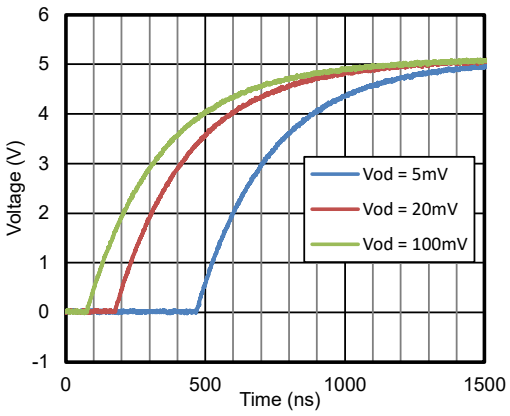


Figure 3. Propagation Delay, Low to High

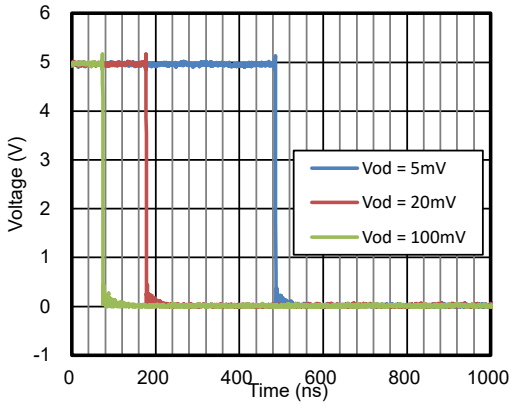


Figure 4. Propagation Delay, High to Low

Detailed Description

Overview

The LMV331X and LMV393X devices feature 158-ns response time and include 4.5 mV of internal hysteresis for improved noise immunity with an input common-mode range that extends 0.1 V beyond the power supply rails, having the ability to operate from 2.5 V to 5.5 V on the supply pin.

The open-drain output allows the output's logic high voltage (VOH) can be configured, or be used in AND functionality. Without the ESD diode between the output pin and the +Vs pin, the output pull-up resistor can be connected to the voltage level independent from the positive supply voltage for level-shifting applications.

Functional Block Diagram

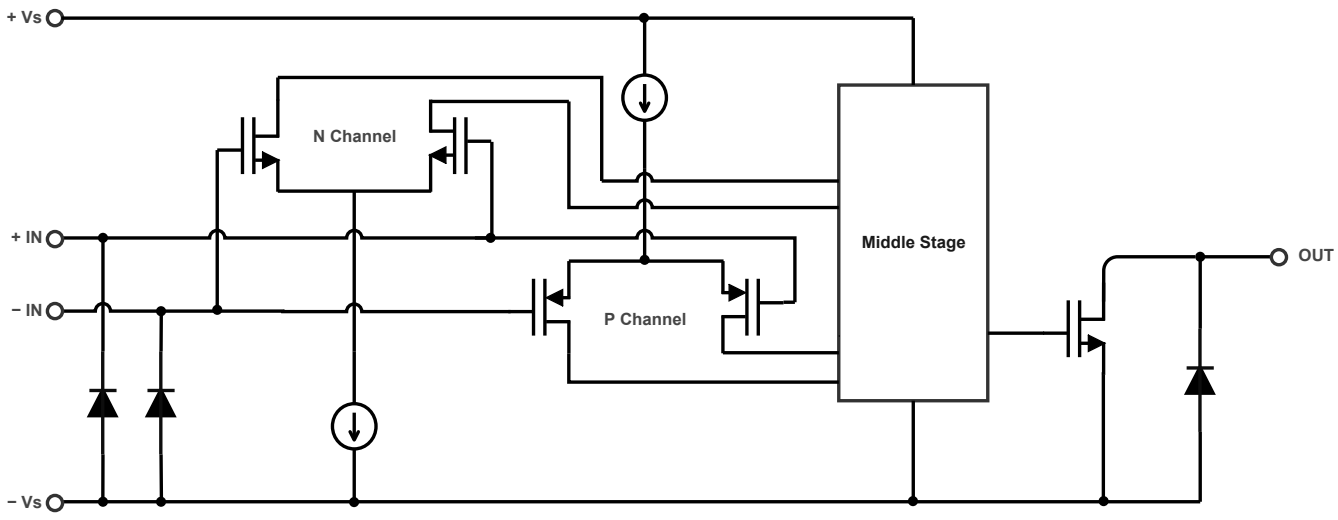


Figure 5. Functional Block Diagram

Application and Implementation

> Note
>
> Information in the following application sections is not part of the 3PEAK's component specification and 3PEAK does not warrant its accuracy or completeness. 3PEAK's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

Application Information

Power Supply Layout and Bypass

The power supply pins of LMV331X and LMV393X families are supposed to have local bypass capacitors (i.e., 0.01 μF to 0.1 μF) within 2 mm for good high-frequency performance. It can also use a bulk capacitor (i.e., 1 μF or larger) within 100 mm to provide large and slow currents. This bulk capacitor can be shared with other analog parts.

A good ground layout improves performance by decreasing the amount of stray capacitance and noise at the comparator's inputs and outputs. To decrease stray capacitance, minimize PCB lengths and resistor leads, and place external components as close to the pins of comparators as possible.

Operation Outside of the Common Input Voltage Range

The following is a list of input voltage situations and the corresponding outcomes:

1. When both −IN and +IN are within the common-mode range:
   a. If the voltage at the −IN pin is higher than the voltage at the +IN pin and the offset voltage, the output is low and the output MOSFET is sinking current.
   b. If the voltage at the −IN pin is lower than the voltage at the +IN pin and the offset voltage, the output is high impedance.
2. When the voltage at the −IN pin is higher than the common-mode voltage range and the voltage at the +IN pin is within the common-mode voltage range, the output is low and the output MOSFET is sinking current.
3. When the voltage at the +IN pin is higher than the common-mode voltage range and the voltage at the −IN pin is within the common-mode voltage range, the output is high impedance.
4. When the voltage at the −IN and +IN pins are both higher than the common-mode voltage range, the output is in an uncertain state.

Typical Application

IR Receiver

The device is an ideal candidate to be used as an infrared receiver shown in Figure 4. The infrared photo diode creates a current relative to the amount of infrared light present. The current creates a voltage across R_D. When this voltage level crosses the voltage applied by the voltage divider to the inverting input, the output transitions. Optional Ro provides additional hysteresis for noise immunity.

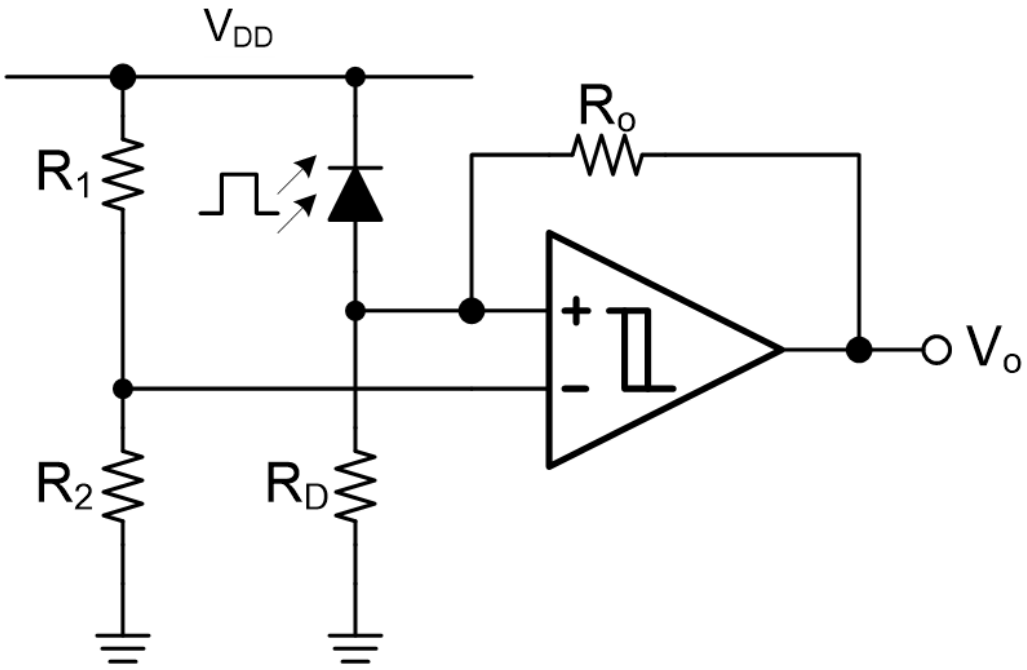
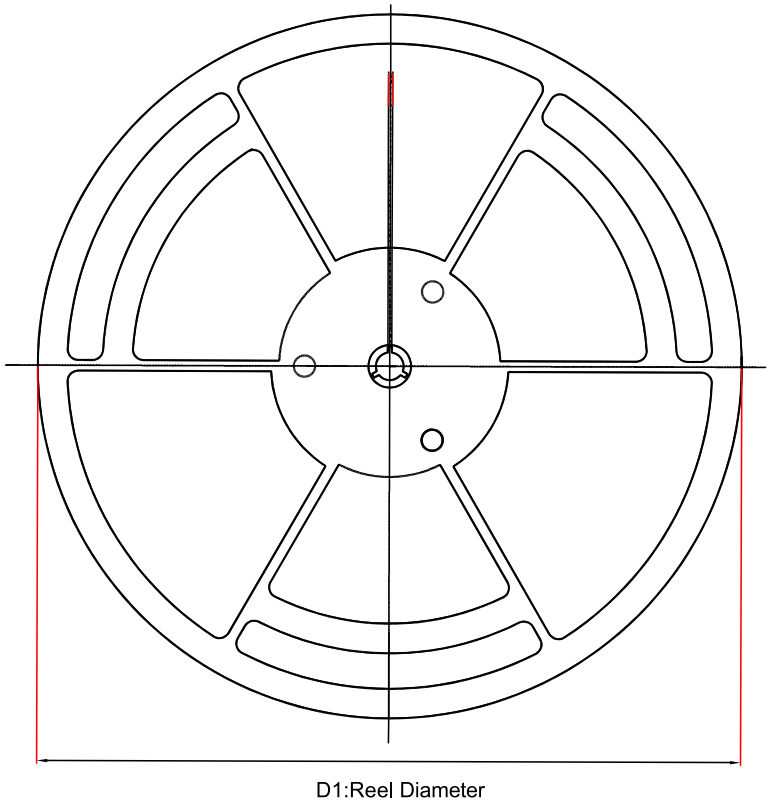
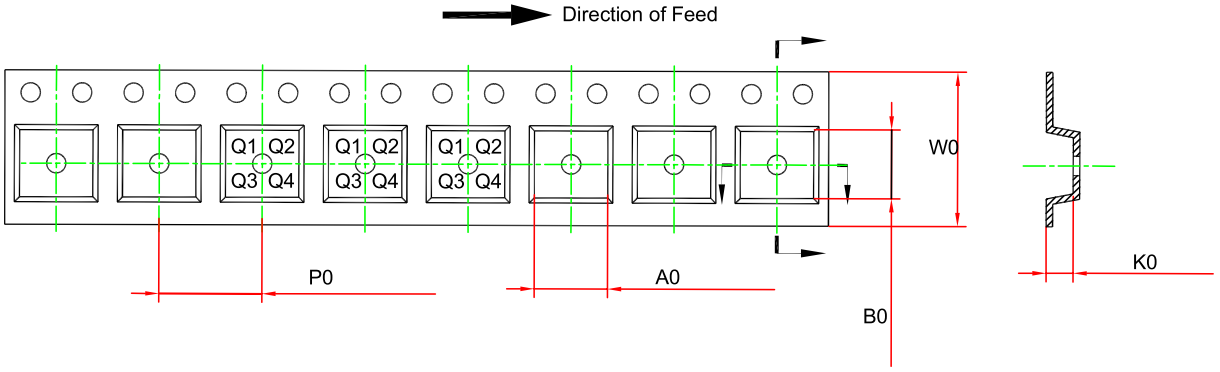


Figure 6. Typical Application Circuit

Tape and Reel Information



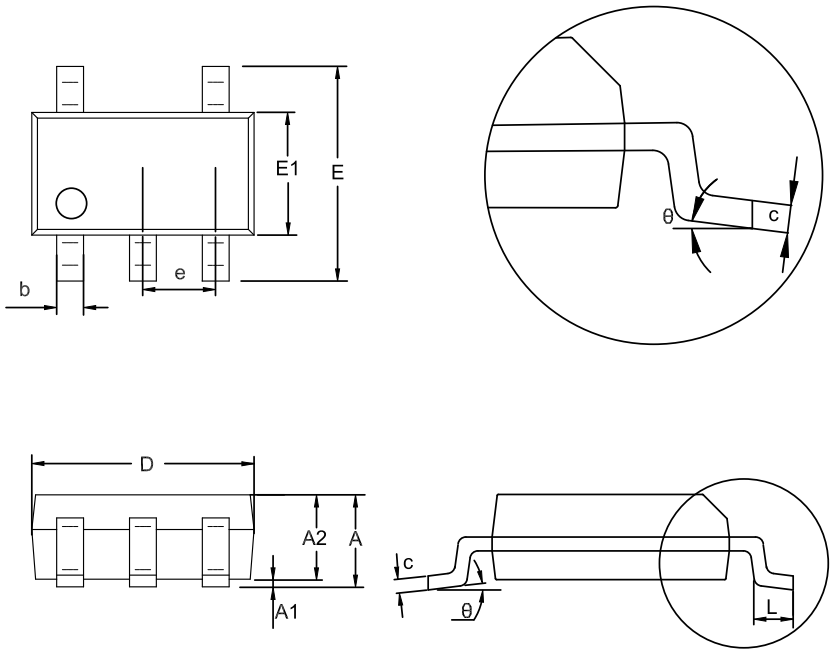


Order Number	Package	D1 (mm)	W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	W0 (mm)	Pin1 Quadrant
LMV331X-SC5R	SOT353 (SC70-5)	178	12.1	2.4	2.5	1.2	4	8	Q3
LMV393X-VS1R	MSOP8	330	17.6	5.2	3.3	1.3	8	12	Q1
LMV393X-SO1R	SOP8	330	17.6	6.5	5.4	2	8	12	Q1
LMV331X-S5TR	SOT23-5	179	12	3.3	3.25	1.4	4	8	Q3

Package Outline Dimensions

SOT23-5

Package Outline Dimensions S5T(SOT23-5-A)



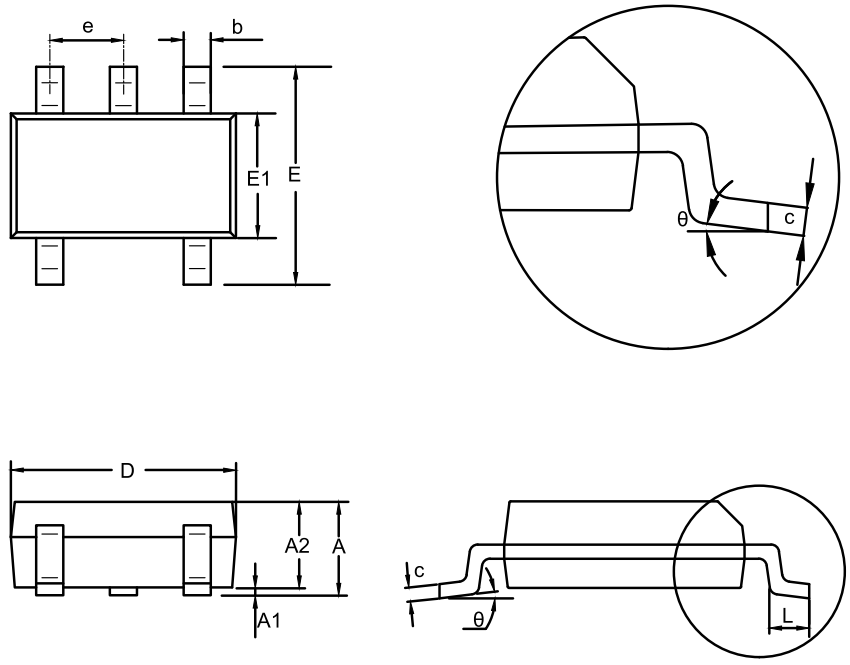
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.050	1.250	0.041	0.049
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.280	0.500	0.011	0.020
c	0.100	0.230	0.004	0.009
D	2.820	3.020	0.111	0.119
E	2.600	3.000	0.102	0.118
E1	1.500	1.720	0.059	0.068
e	0.950 BSC		0.037 BSC	
L	0.300	0.600	0.012	0.024
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

SOT353-5

Package Outline Dimensions SC5(SOT353-5-A)



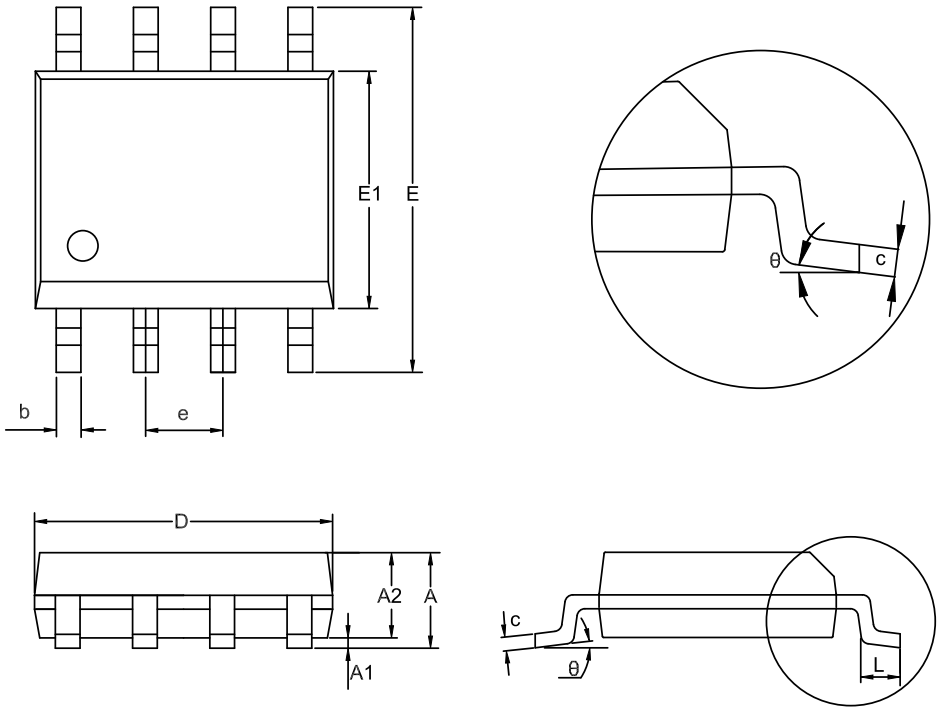
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.850	1.100	0.033	0.043
A1	0.000	0.100	0.000	0.004
A2	0.800	1.000	0.031	0.039
b	0.150	0.350	0.006	0.014
c	0.110	0.230	0.004	0.009
D	2.000	2.200	0.079	0.087
E	2.150	2.450	0.085	0.096
E1	1.150	1.350	0.045	0.053
e	0.650 BSC		0.026 BSC	
L	0.260	0.460	0.010	0.018
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

SOP8

Package Outline Dimensions SO1(SOP-8-A)



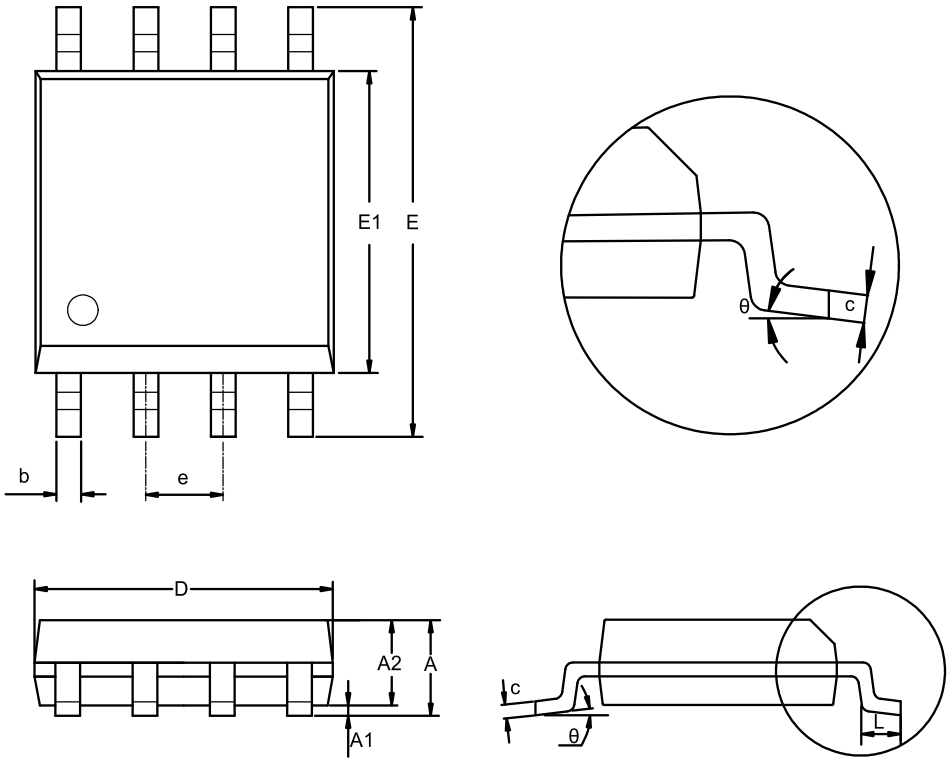
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	1.350	1.750	0.053	0.069
A1	0.050	0.250	0.002	0.010
A2	1.250	1.550	0.049	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270 BSC		0.050 BSC	
L	0.400	1.000	0.016	0.039
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

MSOP8

Package Outline Dimensions VS1(MSOP-8-A)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	MIN	MAX	MIN	MAX
A	0.800	1.100	0.031	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D	2.900	3.100	0.114	0.122
E	4.700	5.100	0.185	0.201
E1	2.900	3.100	0.114	0.122
e	0.650 BSC		0.026 BSC	
L	0.400	0.800	0.016	0.031
θ	0	8°	0	8°

NOTES

1. Do not include mold flash or protrusion.
2. This drawing is subject to change without notice.

Order Information

Order Number	Operating Temperature Range	Package	Marking Information	MSL	Transport Media, Quantity	Eco Plan
LMV331X-SC5R	−40 to 125°C	SOT353 (SC70-5)	A16	MSL1	Tape and Reel,3000	Green
LMV393X-VS1R	−40 to 125°C	MSOP8	V393X	MSL2	Tape and Reel,3000	Green
LMV393X-SO1R	−40 to 125°C	SOP8	V393X	MSL2	Tape and Reel,4000	Green
LMV331X-S5TR	−40 to 125°C	SOT23-5	A16	MSL2	Tape and Reel,3000	Green

(1) The sample will be ready in 1 month.
(2) The sample will be ready in 2 months after manufacture starts.
(3) For future products, contact the 3PEAK factory for more information and samples.

Green: 3PEAK defines "Green" to mean RoHS compatible and free of halogen substances.

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